

## DECLARATION

I, Masaru Hiraoka, of 1-48-20, Shin-Sakuragaoka, Hodogaya-ku, Yokohama-shi, Kanagawa-ken, Japan, declare that:

I am a citizen of Japan and a graduate of Waseda University in Tokyo, Japan:

I am familiar with both the Japanese and English languages;

I have read international application No. PCT/JP03/04818 filed on April 16, 2003 and understand the subject matter of said application.

The attached paper constitutes a true and accurate English translation of said international application.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that will full false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application of any patent issuing thereon.



Masaru Hiraoka

Dated this 1 st day of October, 2004

ATTACHMENT B

2/PARTS

10/511147  
DT04 Rec'd PCT/PTO 14 OCT 2004

TITLE OF THE INVENTION

**HIGH TEMPERATURE RESISTANT SEAL STRUCTURE,  
VALVE COMPRISING THE SAME  
AND AEROSPACE CRAFT SIDE THRUSTER**

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TECHNICAL FIELD

The present invention relates to a high temperature resistant seal structure of an axial directional slide shaft of a valve, etc. handling a high temperature fluid in a side thruster of an aerospace craft, etc. The present invention also relates to a valve comprising this seal structure as well as relates to a side thruster of an aerospace craft comprising this valve.

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BACKGROUND ART

Fig. 2 is a longitudinal cross sectional view of a prior art side thruster valve used in an aerospace craft, etc. and description will be made based thereon.

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As shown in Fig. 2, a thruster valve 01 comprises a valve casing 02. The valve casing 02 comprises a supply port 03 through which working medium a is supplied and a nozzle 04 from which the working medium a is discharged. Within the valve casing 02, the supply port 03 and a nozzle throat portion 05 of the nozzle 04 communicate with each other.

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Also, within the valve casing 02, a valve plug 06 opening

and closing the nozzle throat portion 05 is arranged being connected to one end of a drive rod 07. The drive rod 07 slidably passes through a drive rod through hole 09 of the valve casing 02 and the other end of the drive rod 07 projecting outside of the valve casing 02 is connected to an actuator 08 of a linear actuator, rotary actuator or the like so that the drive rod 07 is driven along the axial direction thereof as shown by a bidirectional arrow X. The actuator 08 is fixed to a fixing member (not shown).

The working medium a supplied through the supply port 03 flows through a space formed between the nozzle throat portion 05 and the valve plug 06 to be jetted from the nozzle 04 so that a thrust of the side thruster is generated. At this time, the actuator 08 drives the valve plug 06 so as to open and close the nozzle throat portion 05 and to change a flow path area thereof. Thereby, the thrust can be changed continuously or step-wise.

In the drive rod through hole 09 of the valve casing 02, an elastomer seal 010 is provided so as to form a seal structure preventing the working medium a from leaking through between the valve casing 02 and the drive rod 07. It is to be noted that the term "elastometer" means a high molecular substance having a rubber elasticity.

Conventionally, in the slidable portion between the valve casing 02 and the drive rod 07 of the thruster valve 01 as mentioned above, such a metal seal as usually used for sealing between stationary faces cannot be used, as the sealing is not sufficiently

achieved because of the sliding motion of the sealing face. Hence, the elastomer seal 010 of an O-ring or the like is used.

For this reason, if a high temperature fluid, such as combustion gas, is used as the working medium a, the elastomer seal 010 often melts because of the heat transmitted from the drive rod 07 so that the combustion gas leaks to form a leak gas b. Thus, the actuator 08 is exposed to the high temperature environment by the leak gas b and there is caused a risk of operation disorder of the actuator 08.

Also, if a structure to protect the elastomer seal 010 and the actuator 08 is to be employed, the valve casing 02 has to be made larger by that extent and there is a problem that this leads to a larger size and mass increase of the side thruster device.

Also, as the side thruster device uses the valve casing 02 made of a metal, the slide resistance between the valve casing 02 and the drive rod 07 becomes large under the high temperature in the drive rod through hole 09. Thus, the drive force of the thruster valve 01 is inevitably made larger and there is caused a problem that this again leads to a larger size of the actuator 08.

## DISCLOSURE OF THE INVENTION

Hence, in order to solve the problems in the high temperature resistant seal structure used in the prior art side thruster for an aerospace craft or the like, it is an object of the present invention to provide a high temperature resistant seal

structure that has no problem of exposing the actuator to the high temperature environment to lead to an operation disorder and to provide a valve that can reduce the valve drive force as well as to provide a side thruster comprising this valve for use in an aerospace craft or the like.

In order to achieve the above-mentioned object, the present invention provides the means as follows:

(1) As a first means, in a high temperature resistant seal structure, provided in a casing into which a high temperature fluid is supplied, comprising a shaft through hole portion into which a shaft to be driven in an axial direction of the shaft is inserted passing through the shaft through hole portion, a liner, made of graphite, comprising a cavity formed therein and slidable holes provided at both end portions of the cavity is provided being inserted into the shaft-through hole portion so that the shaft slidably passes through the slidable holes with a seal state being maintained between the shaft and the liner and a relief hole is provided being bored in a lateral direction relative to the axial direction of the shaft so that the cavity and the outside of the casing communicate with each other.

According to the first means of the present invention constructed as mentioned above, even if the high temperature fluid leaks into the cavity through a minute gap between the shaft and the graphite-made liner, it is discharged outside of the casing through the relief hole. Thereby, the high temperature fluid is prevented from leaking in the axial direction of the shaft and a slide resistance

between the shaft and the graphite-made liner can also be reduced.

(2) As a second means, provided is a valve comprising the high temperature resistant seal structure of the first means, wherein the shaft is a drive rod of a valve plug of the valve and an actuator driving the drive rod in the axial direction of the shaft is connected to an end, projecting outside of the valve, of the drive rod.

According to the second means of the present invention constructed as mentioned above, in the valve comprising the high temperature resistant seal structure of the first means, the actuator is prevented from being exposed to the high temperature environment. Thereby, in addition to the function and effect of the first means, the casing of the valve and the actuator can be made smaller.

(3) As a third means, provided is an aerospace craft side thruster comprising the valve of the second means.

According to the third means of the present invention constructed as mentioned above, in the aerospace craft side thruster comprising the valve of the second means, even if the high temperature fluid of combustion gas, etc. is used as a working medium, the actuator of the thruster valve is prevented from being exposed to the high temperature environment caused by the leaking of the working medium. Thereby, an aerospace craft having a high reliability and reduced mass can be obtained.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a longitudinal cross sectional view of a valve of an aerospace craft side thruster of an embodiment according to the present invention.

Fig. 2 is a longitudinal cross sectional view of a valve of a prior art aerospace craft side thruster.

### BEST MODE FOR CARRYING OUT THE INVENTION

With reference to Fig. 1, a side thruster device for an aerospace craft or the like of one embodiment according to the present invention will be described. Fig. 1 is a longitudinal cross sectional view of a side thruster valve of the side thruster for an aerospace craft or the like of the present embodiment.

As shown in Fig. 1, a thruster valve 1 comprises a valve casing 2. The valve casing 2 comprises a supply port 3 through which working medium a of combustion gas or the like as a high temperature fluid is supplied and a nozzle 4 from which the working medium a is discharged. Within the valve casing 2, the supply port 3 and a nozzle throat portion 5 of the nozzle 4 communicate with each other.

Also, within the valve casing 2, a valve plug 6 opening and closing the nozzle throat portion 5 is arranged being connected to one end of a drive rod 7. The drive rod 7 passes through a drive rod through hole 9 of the valve casing 2 and the other end of the drive rod 7 projecting outside of the valve casing 2 is connected to an actuator 8 of a linear actuator, rotary actuator or the like so that the

drive rod 7 is driven along the axial direction thereof as shown by a bidirectional arrow X. The actuator 8 is fixed to a fixing member (not shown).

5 The working medium is supplied through the supply port 3 flows through a space formed between the nozzle throat portion 5 and the valve plug 6 to be jetted from the nozzle 4 so that a thrust of the side thruster is generated. At this time, the actuator 8 drives the valve plug 6 so as to open and close the nozzle throat portion 5 and to change a flow path area thereof. Thereby, the thrust can be  
10 changed continuously or step-wise.

A graphite liner 20 is provided being inserted into the drive rod through hole 9 of the valve casing 2. The graphite liner 20 comprises a cavity 20a formed therein so that a space is formed between the drive rod 7 and the graphite liner 20. The graphite  
15 liner 20 comprises slidable holes 20b, 20c provided at both end portions of the cavity 20a so that the drive rod 7 slidably passes through both of the slidable holes 20b, 20c with a seal state being maintained between the drive rod 7 and the graphite liner 20.

20 A relief hole 21 is bored elongating from the cavity 20a in the direction substantially orthogonal to the axial direction of the drive rod 7 and passing through both of the graphite liner 20 and the valve casing 2. Thus, when the drive rod 7 is assembled passing through the graphite liner 20, the cavity 20a formed around the drive rod 7 communicates with the outside of the thruster valve 1.

25 In the thruster valve 1 of an aerospace craft side thruster of



the present embodiment as described above, the working medium a supplied through the supply port 3 is jetted from the nozzle 4 corresponding to the opening of the nozzle throat portion 5 set by the valve plug 6. At this time, a portion of the working medium a leaks  
5 as a leak gas b to flow into the cavity 20a through a minute gap between the drive rod 7 and the graphite liner 20 at the slidable hole 20b on the inner side of the thruster valve 1.

The leak gas b entering the cavity 20a is discharged outside of the thruster valve 1 through the relief hole 21 so that the leak gas  
10 b is substantially prevented from leaking in the axial direction of the drive rod 7 through the slidable hole 20c on the outer side of the thruster valve 1 or on the actuator 8 side.

Thereby, the actuator 8 can be prevented from being exposed to the leak gas b of the high temperature working medium a  
15 of the combustion gas or the like and the problem to cause the operation disorder can be solved. Also, the valve casing that has so far been made in a large size for protecting the elastomer seal 010 and the actuator 08 from the leak gas b can be made smaller in size and lighter in weight.

Moreover, as the graphite has a very high heat resistant  
20 temperature and a small friction resistance even in the high temperature, it can stand for the high temperature of the working medium a and the leak gas b. Also, the slide resistance between the drive rod 7 and the graphite liner 20 can be reduced. Thereby, the  
25 actuator 8 also can be made smaller in size.

The seal structure of the thruster valve 1 as described above can be generally effectively applied as a high temperature resistant seal structure of an axial directional slide shaft of a valve, etc. handling a high temperature fluid. By so applying the present seal structure, a leakage of the high temperature fluid along the slide shaft can be prevented and an operation disorder of the surrounding parts and components in the high temperature environment caused thereby can be prevented and an axial directional drive force of the slide shaft can be reduced by the reduced slide resistance. Thus, an effect that the actuator, etc. can be made smaller and lighter is obtained.

If the axial directional slide shaft is a drive rod of a valve plug, by the valve having the above-mentioned high temperature resistant seal structure, an effect to prevent the problem that the actuator is exposed to the high temperature environment to lead to an operation disorder can be obtained, in addition to the above-mentioned effect of making the valve casing and the actuator smaller, etc. Thereby, a reliability of the valve can be enhanced.

Also, in an aerospace craft side thruster using the thruster valve having the above-mentioned high temperature resistant seal structure, the leakage of the high temperature fluid of combustion gas, etc. as the working medium is prevented, the operation disorder of the actuator due to the high temperature environment is prevented and the thruster valve and the actuator can be made smaller so that the entire side thruster device can be made smaller.

Thereby, an aerospace craft side thruster having a high reliability and reduced mass can be obtained.

In the above, while the embodiment according to the present invention has been described, the present invention is not limited thereto but various modifications thereof can be added to the concrete structure within the scope of the invention as appended in the claims.

For example, while the illustration of the relief hole 21 has been shown such that there are provided three relief holes 21 bored in one side portion of the drive rod 7, the number of the relief holes 21 may be one or a plurality. Also, the relief holes 21 may be bored in an arbitrary side portion (including an entire periphery) of the drive rod 7 according to the discharge condition of the leak gas b and the arrangement of the surrounding parts and components.

Also, while the relief hole 21 has been illustrated to elongate linearly in the direction orthogonal to the drive rod 7, if the elongating direction is lateral as a whole relative to the axial direction of the drive rod 7, the relief hole 21 may be inclined or bent on the way of the elongation. Moreover, the relief hole 21 may be connected with a gas discharge pipe (not shown) on the way of the elongation.

#### INDUSTRIAL APPLICABILITY

(1) According to the invention of Claim 1, a high temperature resistant seal structure, provided in a casing into which

a high temperature fluid is supplied, comprising a shaft through hole portion into which a shaft to be driven in an axial direction of the shaft is inserted passing through the shaft through hole portion is constructed such that a liner, made of graphite, comprising a cavity formed therein and slidable holes provided at both end portions of the cavity is provided being inserted into the shaft through hole portion so that the shaft slidably passes through the slidable holes with a seal state being maintained between the shaft and the liner and a relief hole is provided being bored in a lateral direction relative to the axial direction of the shaft so that the cavity and the outside of the casing communicate with each other. Thus, even if the high temperature fluid leaks into the cavity through a minute gap between the shaft and the graphite-made liner, it is discharged outside of the casing through the relief hole. Thereby, the high temperature fluid is prevented from leaking in the axial direction of the shaft. Also, the problem that the surrounding parts and components connected to the shaft end are exposed to the high temperature fluid to lead to an operation disorder can be prevented. Thus, the valve casing that has so far been made in a large size for protecting the parts and components from the high temperature environment can be made smaller in size and lighter in weight. Further, the slide resistance between the shaft and the graphite-made liner can be reduced and the shaft drive force can be also reduced.

(2) According to the invention of Claim 2, a valve comprising the high temperature resistant seal structure of Claim 1 is provided

being constructed such that the shaft is a drive rod of a valve plug of the valve and an actuator driving the drive rod in the axial direction of the shaft is connected to an end, projecting outside of the valve, of the drive rod. By the valve comprising the high temperature resistant seal structure of the invention of Claim 1, the actuator is prevented from being exposed to the high temperature environment. Thus, by the function and effect of the invention of Claim 1, the casing of the valve and the actuator can be made smaller and a reliability of the valve can be enhanced.

10                   (3) According to the invention of Claim 3, an aerospace craft side thruster is provided comprising the valve of the invention of Claim 2. By the aerospace craft side thruster comprising the valve of the invention of Claim 2, even if the high temperature fluid of combustion gas, etc. is used as a working medium, the actuator of the thruster valve is prevented from being exposed to the high temperature environment caused by the leaking of the working medium to lead to an operation disorder. Thus, by the function and effect of the invention of Claim 2, the thruster valve and the actuator can be made smaller, the side thruster device can be made smaller and an aerospace craft having a high reliability and reduced mass can be obtained.